EFFECT OF REINFORCEMENT TO THE SQUARE HOLLOW SECTION ON THE STRENGTH OF FOAMED CONCRETE BEAM

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis, and, in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at University Malaysia Pahang or any other institutions.

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ABSTRAK

Konkrit bertetulang dengan ketumpatan 1600kg / m³ kini digunakan secara meluas sebagai komponen struktur seperti papak kerana ia lebih ringan daripada konkrit biasa. Sementara itu, ia membantu dalam menjimatkan kos dan mengurangkan penggunaan acuan. Seksyen berongga yang diterapkan ke rasuk juga merupakan usaha untuk menjadikan struktur lebih ringan. Processed Spent Bleaching Earth (PSBE) adalah sisa industri yang mempunyai sifat pozzolanic seperti simen. PSBE digunakan untuk sebahagian menggantikan kandungan simen untuk menjadikannya lebih mesra alam. PSBE sebahagiannya menggantikan simen sebanyak 30% daripada jumlah berat kandungan simen. Objektif kajian ini adalah untuk menganalisis kesan pengukuhan bahagian berongga pada kekuatan, pesongan dan mod kegagalan rasuk konkrit berbuih. Tiga spesimen disediakan untuk dianalisis dalam kajian ini. Spesimen 1 boleh dikenali sebagai balok kawalan yang bertindak seperti rasuk biasa tanpa bahagian berongga. Spesimen 2 adalah rasuk dengan bahagian berongga. Sementara itu, spesimen 3 ialah rasuk yang menambah bar keluli di sekeliling bahagian berongga untuk menguatkan bahagian berongga. Saiz rasuk dipasang pada semua spesimen dengan (150 x 200 x 1500) mm. Seksyen berongga yang melaksanakan kedua-dua spesimen adalah dalam saiz 50x50 mm ke tengah rasuk. Setiap spesimen disediakan sebanyak tiga sampel untuk ujian supaya mendapatkan kekuatan lenturan, pesongan dan mod kegagalan. Tiga Linear Variable Displacement Transducer (LVDT) digunakan untuk mengukur pesongan rasuk. Menurut hasilnya, spesimen 1 (pancaran kawalan) mempunyai kekuatan tinggi untuk menahan beban maksimum 31.003kN dan kekuatan lentur sebanyak 6.201 N / mm². Walau bagaimanapun, spesimen 3 dengan tetulang di sekitar pesongan boleh menahan lebih banyak pesongan berbanding dengan spesimen lain. Mod kegagalan untuk semua spesimen dianggap sebagai retak ricih kerana corak retak slaid ditemui. Singkatnya, bahagian berongga yang diterapkan ke rasuk telah memberi kesan kepada kekuatan dan pesongan rasuk walaupun dengan tambahan tetulang di sekitar bahagian berongga. Oleh itu, penting dalam balok menunjukkan kekuatan yang lebih besar dan mengurangkan pesongan dan retak.

ABSTRACT

Foamed concrete with a density of 1600kg/m³ is now widely used as a structural component like slab due to it lighter than the normal concrete. Meantime, it helps in saving cost and reduce the use of formwork. The hollow section that implemented to beam is also an effort to make the structural lighter. Processed Spent Bleaching Earth (PSBE) is an industrial waste which possesses pozzolanic properties like a cement. PSBE used for partially replacing the content of the cement to make it more environmentally friendly. PSBE partially replaced cement up to 30% of the total weight of the cement content. The objective of this study is to analyse the effect of the reinforcement of hollow section on the strength, deflection and mode of failure of the foamed concrete beam. Three specimens prepared to investigate in this study. Specimen 1 can be known as a control beam which acts like a normal beam without a hollow section. Specimen 2 is the beam with a hollow section. Meanwhile, specimen 3 is the beam that added a steel bar around the hollow section to reinforcement the hollow section. The size of the beam was fixed to all specimen with (150 x 200 x 1500) mm. The hollow section that implements to both specimens were in the size of 50x50 mm to the center of the beam. Each specimen was prepared up to 3 unit of samples for testing to get the flexural strength, deflection and mode of failure. Three units of Linear Variable Displacement Transducer (LVDT) were used to measure the deflection of the beam. According to the result, specimen 1 (control beam) had the high strength to resist maximum loading of 31.003kN and flexural strength up to 6.201 N/mm². However, specimen 3 with reinforcement around the deflection can resist more deflection compared to the other specimens. The mode of failure for all the specimens considered as a shear crack as slide cracking pattern found. In short, the hollow section implemented to the beam had affected the strength and deflection of the beam even with added reinforcement around the hollow section. Therefore, it is essential in beam exhibited greater strength and reduce the deflection and cracking.

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%	Percentage
σ	Flexural Strength
δ	Deflection

LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
C-H	Calcium Hydroxide
C-S-H	Calcium Silica Hydrate
GHG	Greenhouse Gases
HB	Hollow Beam
IBS	Industrialized Building System
LVDT	Linear Variable Displacement Transducer
NGO	Non-Governmental Organizations
PSBE	Processed Spent Bleaching Earth
RHB	Reinforced Hollow Beam
SB	Solid Beam
SBE	Spent Bleaching Earth

CHAPTER 1

INTRODUCTION

1.1 Background Of Study

In a double storey house construction, there was lots of formwork being used to support the structural element on the upper floors where formwork constituent 60% of the total cost of the construction (Nemati, 2007). It will be the largest waste of the construction where the formwork like wooden formwork can only be used for one to two times. Even nowadays, there was another type of formwork being used in construction, but mostly construction still prefers the use of wooden as formwork in construction. Generally, formwork is used to support the wet concrete to dry out and form to the shape. The heavier the concrete, more material will be used in formwork to support the wet concrete as a mold. Thus, a lightweight structural element can be an excellent way to solve the problem by having a hollow section in the middle and using a light weight foamed concrete. A hollow foamed concrete was a duality way to reduce the weight of concrete elements. As a result, lightweight concrete needs less formwork to support the concrete. However, unreinforced hollow foamed concrete will primarily reduce the strength of the concrete. Thus, reinforcement was introduced to boost the strength of hollow foamed concrete to the original strength or even stronger.

Foamed concrete was a lightweight concrete used construction industry for a light loaded structure like slab and wall. Foamed concrete was a type of concrete with a large amount of foam or air void inside the concrete to reduce the volume of concrete and make the foamed concrete light. Foamed concrete is constituent from cement, foaming agent, sand and water. There was no aggregate used in foamed concrete to enhance its lightweight properties. Furthermore, the foaming agent was the key to produce foam in the concrete and make concrete light. An only a small amount of the foaming agent needed to mix with concrete to produce foam. The density of foamed concrete was around 400 kg/m^3 to 1600 kg/m^3 whereas foamed

concrete with density of 400 kg/m³ was used for non-loading structure and foamed concrete with density of 1600 kg/m³ can be used for light loading structure. In this study, since the design based on the beam; thus, the density of foamed concrete chosen for 1600 kg/m³.

Besides, concrete was indispensable in construction, especially for the high-rise building. However, concrete need cement as an ingredient to mix up with other materials like aggregate and sand. The production of cement contributes lots of Carbon Dioxide (CO_2), which will cause the greenhouse effect and global warming. To make the concrete more environmentally friendly, the use of cement can be partial replace by waste materials. In this study, the waste material used Processed Spent Bleaching Earth (PSBE). It is a refinery waste from the palm oil industry. PSBE was chosen as a replacement of cement due to its pozzolanic properties. Besides, it an excellent way to solve the landfill disposal problems cause by PSBE. By partially replacing cement with PSBE will surely make the concrete doubly friendlier to the environmental.

In short, this study is conducted to determine the effect of reinforcement to the hollow section on the strength of a foamed concrete beam with the flexural strength, deflection and the mode of failure.

1.2 Problem Statement

As mentioned above, heavy concrete needs lots of formwork to support the wet concrete before it dry. Thus, formwork is largely used in the construction to support and mold the wet concrete. According to Kamran (2007), formwork has constituent up to 60% of the total cost of a construction project. It is a way of destructive to our environment. Thus, the lightweight structure is being introduced nowadays to reduce the use of formwork and make the structure environmentally friendly. To achieve the lightweight structure, the hollow section can be implemented towards the structure. However, a hollow structure like a beam will have lower flexural strength compared to a solid beam. According to the previous study of Lee S. A. (2018), the unreinforced hollow beam has a lower flexural strength than the unreinforced solid beam where the crack pattern propagated under single cracking due to no reinforcement. In his study, Lee is using high density, but lightweight foamed concrete with a hollow section to make the structure lighter. On the other hand, replacing cement with waste materials is a method to make the structural more environmentally friendly as the production of cement will release greenhouses gases which is harmful to the environment. Cement industry contributes about 6% of the greenhouse gases like Carbon Dioxide (CO_2) that causes the world global warming (Ali et al., 2015).

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